Carrier Network Structures and the Spatial Distribution of Air Traffic in the European Air Transport Market, 1996-2006

Aisling J. Reynolds-Feighan*
University College Dublin

This paper characterises and compares the spatial distribution of air traffic in the US and Europe across the network of airports for both continents for the period 1996 to 2006, using annual airline schedules from the Official Airline Guide databases. Several measures of traffic concentration are presented. By decomposing the overall spatial distribution of traffic, aspects of individual airline behaviour may be measured and contrasted, along with measures of multi-market contact among groups of carriers. European and US airlines are characterised in terms of their network strategies and the extent of network competition that they face. [JEL Classification: R12; C43; L93; R40]

1. - Introduction

There is a very substantial literature examining network changes and their implications for competition in the US air transport market following deregulation in the late 1970s. The analysis of hub-and-spoke network systems has received considerable attention within the theoretical and empirical literature there. In Europe, several studies have analysed European network structures using similar approaches and assumptions relating to

* <*aisling.reynolds@ucd.ie*>, School of Economics & Geary Institute. The Author wishes to thank the UCD Geary Institute and UCD Urban Institute Ireland for financial support for this research.

the structure and motivations of European carriers (see for example Brueckner and Pels, 2004; Berechman and deWit, 1996 and Burghouwt *et* al., 2003). European flag carrier networks are presented as broadly similar to US carrier networks in terms of the concentration in space and time of traffic flows in hub-and-spoke networks. However a detailed comparative analysis of the structure and traffic flow organisation in European and US airline networks has not been undertaken to date to validate the implicit assumptions that there are broad similarities between the two continental air transport systems and their carriers.

The internal European air transport market was liberalised in a phased manner over the period 1987-97, beginning the process almost ten years after the US domestic inter-state industry was deregulated. The political landscape in Europe is quite different to that of the US: the air transport industry that developed in Europe reflected the national strategic interests of the member states. State-owned national "flag carriers" were the norm, with an air transport network focused on one or two national/regional capital cities. The process of air transport liberalisation paralleled the political process of forming the single European internal market. This process was completed for the 15 member states in January 1993. The air transport liberalisation process was completed in April 1997. The European "internal aviation market" continues to change in size and scope with the accession of 10 new members states in May 2004 and a further two in 2007. The "European Common Aviation Area (ECAA)"[1], allows non-EU member states to fully participate in the single internal market and be subject to the same carrier licensing, ownership and traffic access rights as the EU25[2]. The ECAA agreement was signed in mid-2006 by the 25 member states of the EU. By 2010, it is expected that 13 non-EU25

---

[1] European Common Aviation Area (ECAA) consists of the following 36 countries: EU25 + Bulgaria, Romania, Norway, Iceland, Croatia, Macedonia, Albania, Bosnia and Herzegovina, Serbia, Montenegro and the United Nations Mission in Kosovo (UNMIK).

[2] The European Union comprises the following 25 countries: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom. Romania and Albania became full members in January 2007.

member states will have signed up to this agreement, liberalising air transport services within a substantially enlarged European area. In the last five years, many of the "European flag carriers" have been in processes of transitioning from state-ownership to private ownership. In most cases this is a phased process with governments gradually reducing their shareholding.

In the US, the airlines were always in private ownership. The largest carriers developed national networks beginning from regional bases, and extending to cover most of the main air transport nodes by strategies of either internal growth or mergers and/or takeovers. Deregulation allowed new entrants to the industry and facilitated the efforts of the incumbent carriers to rationalise and streamline their networks.

This paper compares the European and US air transport markets in terms of the scale, coverage and network structures of the air carriers operating within both markets. In the next section, measures of network coverage, structure, concentration and competition are set out. The decomposition of the Gini index is shown to provide several insightful measures of individual carrier activity and behaviour that can be linked directly to overall continental trends in the spatial and industry share distributions. Section 3 of the paper sets out a descriptive overview of the two air transport sectors and presents a comparison of the air transport systems for the US and Europe, using seating capacity data from the Official Airline Guide (OAG) databases for 1996-2006. The nature of the overall spatial and industrial concentration trends in both continental air transport systems are contrasted and the structures of individual carrier networks are highlighted. Using 2006 data, the top 10 carriers in both continental air transport systems are compared in terms of their network structures and the extent of competition among the carriers. This analysis is presented in Section 4. The paper concludes with a brief summary and some proposals for further research.

The analysis demonstrates very strong differences between European and US carriers in terms of network structures and organisation, and quite different paths for the two industries transitioning to liberalised or deregulated economic policy regimes.

2. - Measures of Network Coverage, Structure, Concentration and Competition

The academic literature has been concerned with measuring and modelling the effects of carrier network structures on several aspects of firm behaviour and decision-making. The airline's network represents its production plan and also its range of products. The network structure gives rise to cost interdependencies among the routes in the carrier's system. The larger 'hubbing' carriers have gained efficiencies associated with economies of scope and density under a variety of circumstances (see for example Brueckner and Spiller, 1994). Borenstein (1989) has shown that the carrier's dominance at its hub airports gives rise to fare mark-ups and increased yields compared to carriers with smaller traffic volumes at these airports. This may be considered as a barrier to entry by new carriers. Network structure influences demand patterns: passengers evaluate the generalised travel costs arising from indirect versus direct routing options. In the recent period, the new entrant low-cost/low-fare carriers have had a growing impact on fares and market shares at the larger airports and have generally tended to offer point-to-point direct service in contrast to the legacy "hubbing" carriers (US Department of Transportation, 1996; General Accounting Office, 1999). In Europe, the low-cost carriers (LCCs) have rapidly grown in size, geographic coverage and market share in the decade since liberalisation was completed. Like the US LCCs, the European LCCs have also tended to offer point-to-point rather than indirect, connecting air services routed through carrier hub airports.

Several summary measures of network structure and organisation have been presented in the literature. The Herfindahl, Theil entropy measure, Coefficient of Variation and Gini Index have been used in a large number of studies to summarise and contrast varying levels of concentration in air transport networks (for example, Reynolds-Feighan, 1998, 2003; Lee, 2003; Burghouwt, Hakfoort and van Eck, 2003). Geographical measures of network structure have also been presented, capturing elements of the spatial configuration of individual airline networks. Reynolds-Feighan (1999, 2003, 2007) compares and contrasts all of these measures for US airlines and suggests that the Gini index captures a particularly useful set of characteristics of carrier networks.

In this paper, the Gini Index, the Herfindahl and Coefficient of Variation (COV) are used to measure various traffic distributions. These measures capture different aspects of a given distribution and for a continuous variable; it may be shown that the three are directly related.

The Gini index may be computed for a continuous variable as

(1) $$G = \frac{2 \quad Cov(x, r_x)}{n\bar{x}}$$

where n is the number of individual airports sampled, $\bar{x}$ is the mean of x, $cov(x,r_x)$ is the covariance between the air traffic distribution, x, and the ranks of airports according to their traffic shares (r_x) from the smallest (r_x=1) to the biggest (r_x=n). Various measures of air traffic may be used. In computing the extent of *spatial concentration*, the variable x might measure total seats available or total number of aircraft movements at each airport in the continental air traffic system. In using the Gini Index to measure *industry concentration*, the measure of traffic might be the total number of seats offered by each carrier, total number of revenue seats filled by carrier or total number of movements by carrier. In decomposing the overall Gini into subgroups, two decomposition schemes have been proposed in the literature (the first in Lerman and Yitzhaki, 1984, 1985 and the second in Yitzhaki and Lerman, 1991 and Yitzhaki, 1994). Lerman and Yitzhaki (1985) show that the overall Gini coefficient based upon i, $(i=1,\ldots,N)$ subgroup components is

(2) $$G(x) = \frac{2\sum_{i=1}^{N} \mathrm{cov}(x_i, F(x))}{\bar{x}} = \frac{2\sum_{i=1}^{N} \mathrm{cov}(x_i, r(x))}{N\bar{x}}$$

F(x) represents the cumulative distribution of *x*. The first decomposition is thus

$$G = \sum_{i=1}^{N} \left[\frac{\text{cov}(x_i, F(x))}{\text{cov}(x_i, F(x_i))} \bullet \frac{2\,\text{cov}(x_i, F(x_i))}{\bar{x}_i} \bullet \frac{\bar{x}_i}{\bar{x}} \right] = \sum_{i=1}^{N} R_i G_i S_i \tag{3}$$

where R_i is the rank correlation *ratio*, G_i is the relative Gini of component *i*, S_i is component *i*'s share of total traffic (Lerman and Yitzhaki, 1984) and $F(x_i)$ is the cumulative distribution of x_i. This decomposition requires that each subgroup has a distribution over the same range as *x*. Thus the number of observations will be the same for each subgroup as it is for *x*. In applying this decomposition to air traffic distributions, we can decompose the overall air traffic across the system of airports (spatial concentrat-ion) by individual carriers or by groupings of carriers. Industry concentration may be decomposed by individual airport or by groups of airports.

The second decomposition scheme put forward by Yitzhaki and Lerman (1991) and refined in Yitzhaki (1994) allows subgroups to cover a subset of the range of *x*. This decomposition is given as

$$G(x) = \sum_i S_i G_i^* O_i + G_b \tag{4}$$

where G_i* is the relative Gini coefficient for carrier *i* over airports in its network, S_i is the traffic share for carrier *i* as before, O_i is an "overlapping index" and G_b is "between group" concentration. The overlapping index, O_i, is discussed at length in Milanovic and Yitzhaki (2002) and defined as:

$$O_i = \frac{\text{cov}(x_i*, F(x*))}{\text{cov}(x_i*, F(x_i*))} \tag{5}$$

the *ratio* of the covariance between carrier *i*'s traffic distribution ranked by the overall air traffic distribution for airports served by carrier *i*, to the covariance of carrier *i*'s traffic distribution ranked by its own air traffic distribution across airports in its network. The O_i component for carrier *i* is the sum of overlaps with *all* other carriers. This component may be interpreted as a measure of multi-market contact for individual carriers with all other carriers (see Evans and Kessides, 1994 and Fournier and Zuelke, 2004). Yitzhaki and Lerman (1991) argue that the O_i component could be further decomposed to yield measures of overlap between pairs of subgroups, yielding measures of multi-market contact between pairs of individual carriers when applied to air traffic distributions.

For the market overlap measure and following from Yitzaki and Lerman (1991), the O_i component is further decomposed by individual carriers in the following way:

$$O_{ij} = \frac{\mathrm{cov}(x_i*, F(x_j*))}{\mathrm{cov}(x_i*, F(x_i*))} \tag{6}$$

and yields a measure of market overlap between carrier *i* and carrier *j*. We note that $O_{ij} \neq O_{ji}$.

The "between group" concentration is twice the covariance between the average traffic for each carrier (over all of the airports served) and its mean rank in the overall traffic distribution, divided by the overall average air traffic, *i.e.*

$$G_b = \frac{2\,\mathrm{cov}(\bar{x}_i*, \bar{F}(x*))}{\bar{x}} \tag{7}$$

The Herfindahl Index gives the summed, squared traffic shares at each airport in a carrier's network. It gives a progressively higher weight to the busier airports in the network. Generally speaking values of less than 0.10 are not considered concentrated; values between 0.1 and 0.18 are considered moderately concentrated, while values greater than 0.18 are considered heavily concentrated.[3] The Herfindahl Index (H) is computed for a traffic distribution x in the following way:

$$H = \sum_{i=1}^{n} (S_i)^2 \tag{8}$$

where S_i is the share of total traffic at airport i (or airline i's share of total traffic in the case of industry concentration). The Herfindahl Index is related to the Gini Index (G) as

$$H = \frac{1}{n}\left(\frac{\sqrt{3G}}{\rho(x,r_x)}\right)^2 + 1 \tag{9}$$

where $\rho(x,r_x)$ is the correlation between x and its rank (r_x).

The Coefficient of Variation (COV) is a dimensionless measure of the ratio of the standard deviation of a distribution to its mean. It allows for comparison of widely differing distributions. Distributions with COV < 1 are considered low-variance, while those with COV > 1 are considered high-variance. The Coefficient of Variation (V) is computed as

$$V = \frac{\sigma_x}{\bar{x}} \tag{10}$$

where σ_x is the standard deviation of the variable x and $\bar{x}$ is the sample mean of x. The Coefficient of Variation (V) is related to the Gini Index (G) and Herfindahl Index in the following way:

[3] The Herfindahl may be normalised to take on values from 0 to 1 by adjusting the score in the following way:

$$H* = \frac{H - 1/n}{1 - 1/n}$$

$$(11) \qquad V = \sqrt{nH - 1} \qquad \text{and} \qquad V = \frac{\sqrt{3G}}{\rho(x, r_x)}$$

The focus in this paper will be on comparing the individual carrier components from the Gini decompositions for European and US carriers. The availability of a consistent, comprehensive and up-to-date database for both continental markets makes such a comparison possible for the first time.

3. - Descriptive Overview of the US and European Air Transport Systems

The Official Airline Guide "OAG Max Historical Plus databases" contain daily airline schedules for every airline in every country. The database facilitates the generation of annual traffic distributions by carrier and airport for any given year. In this study, the annual traffic flows were generated for the US market (traffic by US and non-US carriers originating from all airports within the US, whether or not the destinations were US based) and the European liberalised market (consisting of the 25 member states of the European Union in 2006). Scheduled and non-scheduled seats available on non-stop market segments serviced by all categories of jet aircraft (including regional jets) are included. Airports and carriers with at least 1,000 seats are counted and a traffic matrix for each continental region is constructed for 2006.

Table 1 gives a broad overview of the two regional systems, detailing the number of airports and carriers operating in each regional air transport system for the period 1996-2006. The adjusted Spatial Gini Index and adjusted Industry Gini Index scores are illustrated for the EU25 and US markets in Graph 1. These statistics give a summary measure of the extent of concentration in the distribution of available seating capacity across the set of airports (Spatial Gini) and the airline industry (Industry Gini). The adjusted Gini Index takes account of the changes in the number of airports receiving service between different years (in the case of the Spatial Gini) and changes in the number of airlines for the industry concentration measure. The following adjustment is applied (see Reynolds-Feighan, 2007 for the derivation of this adjustment factor):

$$G(x_i) = \left(\frac{n_i}{N}\right) G(x_i^*) + \left(\frac{N - n_i}{N}\right) \tag{12}$$

where N is the maximum number of airports receiving service in the analysis period and n_i is the number of airports receiving service in year i. $G(x_i^*)$ is the raw Gini score in year i.

The two continental systems have a similar number of airports receiving jet services, though the number is increasing more rapidly in Europe compared with the US. Europe is served by a

TABLE 1

BASIC DESCRIPTIVE STATISTICS COMPARING EUROPEAN AND US AIRPORTS SYSTEMS

Europe	EU25		
	1996	2000	2006
Number of EU25 airports receiving jet services	253	278	308
Total number of carriers serving EU25	207	247	284
Number of "domestic" carriers (EU25)	124	107	115
Number of EU25 airports served by Top 10 EU25 carriers	144	198	245
(Percentage)	*56.9*	*71.2*	*79.5*
Available departing seats	408,772,139	522,758,226	674,356,288
Percentage available seats by carriers based in region	84.3	86.2	85.6

(continued on next page)

(continued) TABLE 1

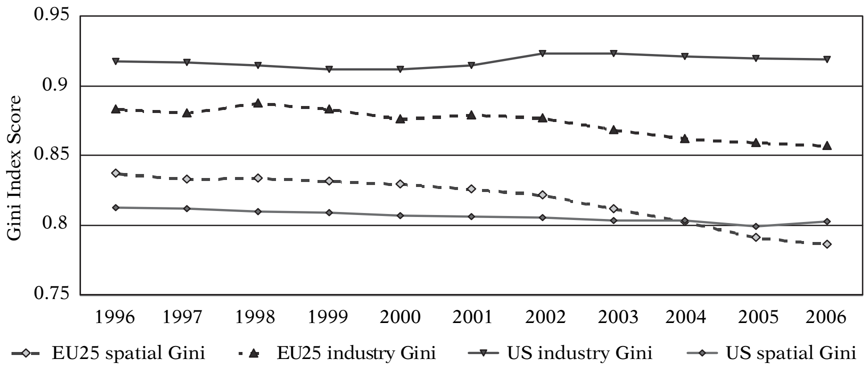
BASIC DESCRIPTIVE STATISTICS COMPARING EUROPEAN AND US AIRPORTS SYSTEMS

US			
	1996	2000	2006
Number of airports receiving jet services	229	240	278
Total number of carriers serving US	117	137	123
Number of "domestic" carriers (US)	28	33	32
Number of US airports served by Top 10 US carriers	214	224	265
(Percentage)	*93.4*	*93.3*	*95.3*
Available departing seats	903,987,982	984,597,844	952,463,923
Percentage available seats by carriers based in region	95.5	95.0	95.5

much larger number of airlines — both EU25 carriers and non-EU25 carriers than the US. Some 37% of all airlines operating in the European market are locally licensed while just 12% of US

GRAPH 1

SPATIAL & INDUSTRY CONCENTRATION IN EU25 AND US AIR TRANSPORT MARKETS 1996-2006



airlines are domestic. However the traffic share operated by the "local" carriers in each case is very large, 80% in Europe and 95% in the US. In 2006, there were 41% more seats available in the US compared with the EU25 countries.

The spatial concentration scores are very similar in Europe and in the US, reflecting the dominance of the largest airports in the respective airport hierarchies. In Europe, spatial concentration has reduced since 1996 and at an accelerated pace since 2001. This reflects the fact that more airports are being serviced in the liberalised internal market, and traffic is more dispersed across the larger system of airports. This is in marked contrast to the US experience following deregulation in 1977 and 1978. In the five years immediately following deregulation, the US airports system (receiving jet air services) contracted significantly, with a concomitant increase in spatial concentration. Spatial concentration as measured by the adjusted Spatial Gini Index has remained reasonably stable since the mid-1980s (Reynolds-Feighan, 2007). In the post 2002 period, there have been increases in the number of airports being served by regional jets and this is reflected in the OAG database statistics.

The industry concentration is higher in the US, reflecting the relatively smaller number of carriers serving the market and the dominance by the small number of US carriers of the market. Table 1 shows that 95% of all available seats are offered by US carriers over the last decade. In Europe, 85% of seats are offered by EU25 licensed carriers. In both cases however the high industry concentration scores reflect the dominance of a small number of carriers in the distribution of traffic shares.

Table 2 presents a more detailed breakdown of the EU25 member states between 1996 and 2006. The number of airports in each member state receiving jet services has increased in all but 2 of the EU15 countries and in five of the 10 accession countries associated with the 2004 EU enlargement (hereafter referred to as the EU+10). Traffic was at relatively low levels in these states in 1996 and has grown significantly in the decade since. The last column in Table 2 gives the percentage change in traffic between 1996 and 2006. The Gini Index was calculated for the traffic distribution across the set of airports in each member state in 1996 and in 2006 and these scores are recorded in Table

TABLE 2

TRAFFIC DISTRIBUTION PATTERNS FOR EU25 MEMBER STATES, 1996 & 2006

EU Member State	Number of Airports Receiving Jet Services		Gini Index			Percentage Change in Available Departing Seats
	1996	2006	1996 (Raw)	1996 (Adjusted)	2006	1996-2006
Austria	6	6	0.752	0.752	0.729	58.6
Belgium	2	2	0.498	0.498	0.382	11.1
Denmark	7	8	0.757	0.788	0.838	6.4
Finland	15	16	0.799	0.812	0.811	46.2
France	36	43	0.814	0.845	0.838	28.8
Germany	23	28	0.759	0.802	0.724	54.7
Greece	14	23	0.814	0.887	0.819	68.4
Ireland	5	5	0.670	0.670	0.626	140.9
Italy	30	39	0.740	0.800	0.713	63.6
Luxembourg	0	1				
Netherlands	3	5	0.664	0.798	0.771	62.9
Portugal	9	10	0.708	0.737	0.719	68.0
Spain	34	37	0.728	0.750	0.727	110.8
Sweden	23	23	0.762	0.762	0.806	-0.4
United Kingdom	31	39	0.831	0.865	0.761	94.1
Cyprus	3	3	0.512	0.512	0.368	52.4
Czech Republic	1	4		0.750	0.733	217.2
Estonia	1	1				129.4
Hungary	1	2		0.500	0.494	114.9
Latvia	1	1				239.0
Lithuania	3	3	0.517	0.517	0.492	59.4
Malta	1	1				15.2
Poland	4	10	0.666	0.866	0.673	251.6
Slovakia	2	3	0.368	0.578	0.589	1,357.3
Slovenia	1	2	0.000	0.500	0.493	106.0

Source: Author's calculations from the OAG Historical Max Plus Databases, 1996 & 2006.

2 also. The raw score in 1996 gives the concentration measure for the set of airports served then. The "adjusted Gini Index" takes account of the change in the number of airports between 1996 and 2006. In almost all of the member states, the traffic distribution has become less concentrated in the ten years since liberalisation was completed. The only exceptions are Denmark, Sweden and Slovakia. This contrasts with the US experience where deregulation resulted in a significant and sustained contraction in the size of the system of airports receiving jet air services after 1978.

Table 3 reports descriptive statistics for the ten largest US and EU25 carriers in 2006. The table shows the significantly greater size of largest US carriers compared with the European carriers in terms of available departure seating capacity offered and the number of airports served. The US carrier data includes services from wholly owned subsidiary airlines. There is a much smaller number of domestic US airlines (jet services only), but they are carrying significantly more traffic. Southwest Airlines' departure seating capacity from US airports in 2006 was two and a half times that of Lufthansa's; indeed each of the top 7 US carriers would be significantly bigger than the top ranked European carrier, Lufthansa.

The US carrier domestic and international networks are large and extensive, though the traffic share carried "internationally" is significantly smaller than for the typical EU25 carrier. Proportionately, the European carriers' international networks are much larger and services on North Atlantic markets as well as other inter-continental markets tend to be related to historical and cultural linkages for the individual member states.

There are three low-cost carriers (LCCs) among the top 10 carriers in both systems, all of whom operate almost exclusively domestic networks.[4] The two main airports or hubs or focal cities for each carrier are listed in Table 3 along with the percentage of

[4] Domestic in this study refers to the EU25 member states in Europe and the 48 States for the USA. The LCC carriers in Europe are Ryanair (FR), Easyjet (U2) and Air Berlin (AB), while the three US LCC carriers are Southwest (WN), Airtran (FL) and America West (HP).

TABLE 3

TOP 10 US & EU25 CARRIERS IN 2006 - DESCRIPTIVE STATISTICS

Carrier Name	Carrier Code	Country of Registration	EU25 Airports Served	Non-EU25 Airports served	Top/Busiest Airport in Carrier Network	Percentage of Total System Seats at Busiest Airport	Second Busiest Airport In Carrier Network	Percentage of Total System Seats at 2nd busiest Airport	Distance between Top 2 Airports (in kilometres & Statute Miles)	
Lufthansa German Airlines	LH	Germany	76	49	FRA	35.10	MUC	17.19	298km	185
Air France	AF	France	82	29	CDG	36.80	ORY	16.18	35km	22
Ryanair	FR	Ireland Republic of	115	3	STN	19.80	DUB	8.59	469km	291
British Airways	BA	United Kingdom	87	41	LHR	45.10	LGW	13.17	40km	25
Iberia	IB	Spain	70	10	MAD	35.70	BCN	17.10	483km	300
Easyjet	U2	United Kingdom	67	0	LTN	9.80	STN	9.02	40km	25
Alitalia	AZ	Italy	52	23	FCO	29.30	MXP	22.26	509km	317
SAS Scandinavian Airlines	SK	Sweden	65	33	CPH	32.70	ARN	25.09	547km	340
KLM-Royal Dutch Airlines	KL	Netherlands	50	26	AMS	63.10	LHR	2.51	369km	229
Air Berlin	AB	Germany	71	6	PMI	18.20	TXL	8.14	1,657km	1,029

Carrier Name	Carrier Code	Country of Registration	US Airports Served	Non-US Airports served	Top/Busiest Airport in Carrier Network	Percentage of Total System Seats at Busiest Airport	Second Busiest Airport In Carrier Network	Percentage of Total System Seats at 2nd busiest Airport	Distance between Top 2 Airports (in kilometres & Statute Miles)	
Southwest Airlines	WN	USA	63	0	LAS	7.2	MDW	6.60	2,443km	1,518
American Airlines	AA	USA	143	76	DFW	22.8	ORD	13.30	1,289km	801
Delta Air Lines	DL	USA	203	85	ATL	30.4	CVG	10.16	599km	372
United Airlines	UA	USA	145	34	ORD	21.0	DEN	13.57	1,426km	886
Northwest Airlines	NW	USA	164	21	MSP	22.1	DTW	21.76	847km	526
US Airways	US	USA	103	42	CLT	22.8	PHL	17.74	721km	448
Continental Airlines	CO	USA	135	104	IAH	29.8	EWR	20.69	2,250km	1,398
America West Airlines	HP	USA	75	10	PHX	36.2	LAS	17.31	413km	257
Airtran Airways	FL	USA	49	1	ATL	33.9	BWI	6.42	929km	574
Alaska Airlines	AS	USA	44	10	SEA	31.0	PDX	9.67	209km	130

Source: Author's calculations from the OAG Historical Max Plus Databases, 2006.

total "domestic" departure seating capacity operated. The European "Full Service Carriers" (FSCs) have a significantly higher share of total traffic departing from their top ranked airport or main hub than their US counterparts. The average traffic share for the European airlines from their top hub is 33%, while the average is 25% for US carriers. The high share for KLM reflects the fact that a very large share of its departures terminate outside the EU25. The LCCs in Europe have a lower proportion of flights originating from their top hub/focal city. In the US, Airtran Airways (FL) and America West Airlines (HP) have higher proportions than the US FSCs. In the next section, network structure and organisation will be explored in more detail using Gini decomposition and other measures of concentration.

The distance between the European carriers' first and second ranked airport is relatively small. The average distance among the top 9 is 310 km (193 miles). Air Berlin is very much the exception with 1,657 km between its top 2 airports. In the US by contrast, there is a more substantial distance between the two largest hub airports in carriers networks, with the average distance being 910 km (565 miles). The US FSCs operate interactive hub-and-spoke systems, where the regional hubs gather and distribute traffic within the network. There is a substantial traffic flow between the hubs for these carriers. In Europe, the FSC hubs for Lufthansa, Air France and BA particularly, tend to specialise in serving either domestic or international traffic (extra-EU25) and there is relatively little interaction by air between the hubs themselves. This is a fundamental difference in the structure and flow organisation among the two groups of carriers.

Table 4 gives a comparison of the traffic flow concentration statistics for each of the top 10 carriers in both systems. The Gini and Herfindahl Indexes as well as the Coefficient of Variation are calculated for each carrier and the ranking of carriers are given based on these measures in each case. These measures capture different aspects of the traffic distribution.

The Herfindahl Index scores in Table 4 reflect the traffic shares at the busiest airports reported in Table 3. Where the Gini Index and COV are sensitive to changes in the number of airports

Table 4

COMPARISON OF GINI, HERFINDAHL & COV STATISTICS FOR TOP 10 US & EU25 CARRIERS IN 2006

Carrier	Scores			Rank		
	Carrier Gini	Coefficient of Variation	Herfindahl Index	Carrier Gini	Coefficient of Variation	Herfindahl Index
Lufthansa German Airlines	0.795	3.390	0.162	3	4	5
Air France	0.776	3.586	0.167	4	3	4
Ryanair	0.698	2.517	0.063	8	8	8
British Airways	0.805	4.325	0.224	1	2	2
Iberia	0.771	3.222	0.160	5	5	6
Easyjet	0.638	1.416	0.044	10	10	10
Alitalia	0.744	2.662	0.153	6	7	7
KLM-Royal Dutch Airlines	0.717	4.373	0.395	7	1	1
SAS Scandinavian Airlines	0.796	3.189	0.169	2	6	3
Air Berlin	0.683	1.873	0.063	9	9	9

Carrier	Scores			Rank		
	Carrier Gini	Coefficient of Variation	Herfindahl Index	Carrier Gini	Coefficient of Variation	Herfindahl Index
Southwest Airlines	0.495	1.025	0.032	10	10	10
American Airlines	0.785	3.386	0.087	1	4	8
Delta Air Lines	0.785	4.603	0.109	2	1	5
United Airlines	0.770	3.384	0.085	4	5	9
Northwest Airlines	0.761	4.037	0.105	5	3	6
US Airways	0.749	2.987	0.095	6	7	7
Continental Airlines	0.774	4.247	0.140	3	2	2
America West Airlines	0.725	3.384	0.164	7	6	1
Airtran Airways	0.605	2.342	0.130	9	8	3
Alaska Airlines	0.692	2.132	0.123	8	9	4

Source: Author's calculations from the OAG Historical Max Plus Databases, 2006.

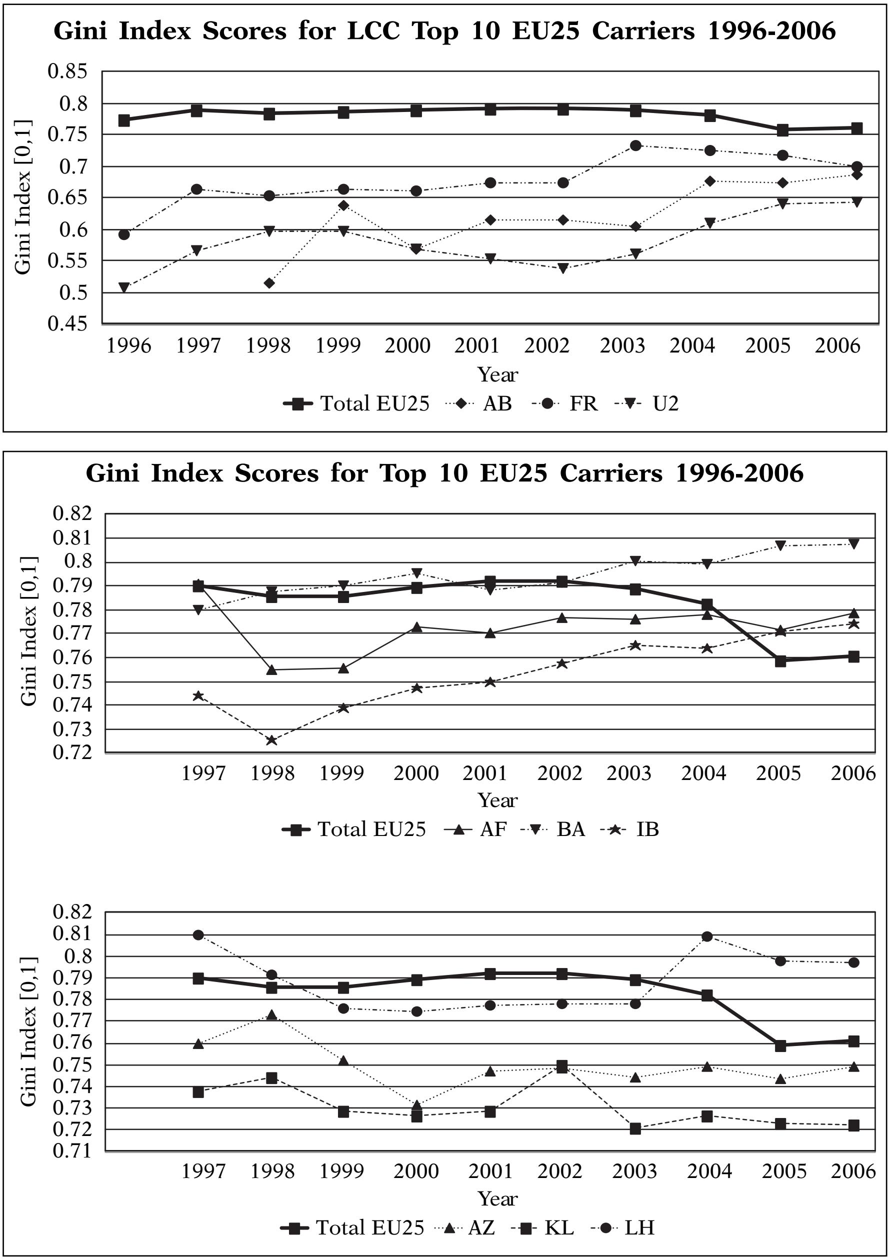
in the distribution, the Herfindahl is far less sensitive, particularly if traffic levels are very low. The value for KLM is very high, with moderately high values for BA, America West, and SAS reflecting the very high traffic shares at the top airport in each of these airlines' networks. In essence this measure indicates the extent of the dominance of the top one, two or three hubs in an air carriers' network and the ranking of carriers using this measure corresponds directly with the ranking from summing the traffic at the top three busiest airports.

All of the COV scores in Table 4 display high variance, with the possible exception of Southwest Airlines. The COV scores will be more sensitive to the total number of airports in the network, unlike the Herfindahl values. The high COV value for Delta Airlines with a low Herfindahl score reflects the large number of observations in the Delta network and the large variation in traffic levels across all of the airports.

The Gini Index measures the extent to which the actual traffic distribution differs from an equal distribution across all airports in a carrier's network. All airports are included in the assessment and each airport is equally weighted. The value of the Gini Index ranges from 0 to 1, with a higher score indicating a more unequal distribution. The scores in Table 4 are generally higher for the EU25 carriers compared to the US carriers. This reflects the dominance of the main airport in most EU25 networks, including those of the LCCs. The Gini score is also affected by the size of the network, so that a high traffic share at the top airport in a large network will have a higher Gini Index score than a high traffic share in a small network. In the next section, the Gini Index for the overall spatial traffic distribution in the continental system is decomposed using the schemes detailed in *(3)* and *(4)* earlier, in order to identify the extent to which individual carriers contribute to overall concentration and the extent of multimarket contact or network competition among pairs of carriers. For the European carriers, Graph 2 illustrates the individual carrier Gini Index scores for the period 1996-2006. Equivalent scores for US carriers have been extensively reported and discussed elsewhere (see Reynolds-Feighan, 2001; 2007). In Graph 2, the Gini Index

GRAPH 2

INDIVIDUAL CARRIER GINI INDEX SCORES FOR TOP EU25 CARRIERS, 1996-2006



scores for the LCCs have been increasing steadily over the period 1996-2006, as they have greatly expanded their networks and concentrated development on a small number of key nodes or carrier hubs. These nodes are the focus point for development of new air transport services and have tended to be secondary European airports close to large urban areas or conurbations. In the US, the LCC carriers networks became less concentrated as the network size expanded.

For three of the European FSCs, namely Air France, BA and Iberia, the networks have become more concentrated and this is partly due to the increase in the number of airports both within the EU25 and beyond in these carriers' networks. For KLM, Alitalia and Lufthansa by contrast, the degree of concentration in the traffic distribution within their networks has declined since 1996.

The three measures of concentration provide different insights into the traffic distribution pattern across an airline's network. The Herfindahl captures the extent to which the top two or three airports dominate the distribution; the COV reflect the range of traffic levels across the network of airports relative to the mean. The Gini index captures the deviation of actual traffic levels across all of the airports from an equal distribution, weighting each airport equally. Thus the Gini index provides information about the traffic flows at middle and lower ranking airports in a carrier's network.

4. - Decomposition of Continental Spatial Gini Index Scores and an Assessment of Network Overlap and Competition

The spatial Gini Index scores reported in Table 1 for the EU25 and US airport systems were decomposed by carrier using the schemes explained in *(3)* and *(4)* earlier. The decomposition components give information for each carrier on the following aspects of their traffic distributions:

• G_i: Gini Index for carrier i measuring the traffic distribution across all airports in the continental system

• G_i*: Gini Index for carrier i measuring traffic distribution across airports served by carrier i

- S_i: Carrier *i*'s share in total system traffic
- O_i: Overlap between carrier *i*'s traffic distribution and all other carriers traffic distribution
- R_i: (so-called Gini correlation) ratio of the covariance between carrier *i*'s traffic distribution and ranking of airports within its network with carrier *i*'s traffic distribution ranked by the overall traffic distribution
- O_{ij}: pairwise carrier overlap comparisons

Tables 5 and 6 report the decomposition components for the top 10 carriers in the EU25 and US air transport systems. Table 5 deals with the US carriers. The high traffic shares for US carriers, particularly the top four contribute significantly to the overall pattern of traffic concentration in the US system (the raw contribution is measured as the product $S_iR_iG_i*(n_i/N)$). The traffic distribution of the top four carriers dictate in a significant way the overall ranking of airports in the US system. The individual carriers' Gini scores were discussed earlier (G_i*). The measure *Gi* is very high for all of the carriers (>0.8), with the exception of Alaskan Airlines and AirTran. This means that for most carriers, their traffic distributions are concentrated at the higher ranked airports in the continental airport system, and that generally busier airports have higher service levels from the carriers. The Alaskan score suggests that its network is less focused on the top of the US airports hierarchy. The market overlap measure (O_i) for the US carriers varies from 1.04 for Southwest Airlines to 1.67 for America West Airlines, indicating a moderate degree of overlap with the traffic of all other carriers in each case. The low overlap for Southwest reflects the fact that this carrier provides high levels of service to airports with low service levels from other carriers.

Table 6 gives the decomposition results for the EU25 carriers. It can be noted that the carrier shares are substantially lower for the top EU25 carriers and therefore they have smaller contributions to the overall spatial concentration of air traffic. There is a much higher degree of overlap among the EU25 carriers; this is reasonable given that much of the international traffic is focused on the same subset of national capital city

TABLE 5

DECOMPOSITION COMPONENTS FOR US CARRIERS IN 2006

	Aitran Airways	Alaska Airlines	America West Airlines	Continental Airlines	US Airways	Nortwest Airlines	United Airlines	Delta Air Lines	American Airlinea	Southwest Airlines
	FL	AS	HP	CO	US	NW	UA	DL	AA	WN
Total Seats Available (Departing from US airports)	29086789	24025036	33454322	73190307	73804274	78568605	110123352	129925318	135598127	149307392
Average seats per Airport	593607.9	546023.5	446057.6	542150.4	716546.3	479076.9	759471.4	640026.2	948238.7	2369958.6
Standard Deviation	1390193.9	1164319.9	1509337.7	2302764.4	2140351.4	1933943.5	2569942.6	2945973.4	3211011.3	2430125.4
Number of Airports Served	49	44	75	135	103	164	145	203	143	63
COV(X_i,$F(X)$)	11941465	8620179	14290745	29945174	28698533	29954058	45180976	50372811	56683142	56570545
COV(X_i*,$F(X$*))	14330662	28388336	20239365	30629604	42481911	31855696	48191643	51727479	58207154	38502762
COV(X_i*,$F(X_i$*))	8804658	8307371	12127788	28320542	27652092	29882632	42412834	50972790	53229899	36939925
COV(X_i,$F(X_i)$)	13482270	11397324	15425452	32379785	33306836	33465910	48140612	54245892	59937212	65687781
Concentration *Ratio*	0.821	0.718	0.854	0.818	0.778	0.762	0.821	0.775	0.836	0.758
Airports Served	49	44	75	135	103	164	145	203	143	63
Gini - served	0.605	0.692	0.725	0.774	0.749	0.761	0.770	0.785	0.785	0.495
Gini - all apts	0.927	0.949	0.922	0.885	0.903	0.852	0.874	0.835	0.884	0.880
S_i	0.031	0.025	0.035	0.077	0.077	0.082	0.116	0.136	0.142	0.157
R_i	0.886	0.756	0.926	0.925	0.862	0.895	0.939	0.929	0.946	0.861
O_i	1.628	3.417	1.669	1.082	1.536	1.066	1.136	1.015	1.094	1.042
n_i/N	0.188	0.169	0.286	0.511	0.391	0.620	0.549	0.767	0.541	0.241
N-n_i/N	0.812	0.831	0.714	0.489	0.609	0.380	0.451	0.233	0.459	0.759
$S_iR_iG_i$*(n_i/N)	0.003	0.002	0.007	0.028	0.020	0.035	0.046	0.076	0.057	0.016
$S_iR_i(N$-$n_i)/N$	0.022	0.016	0.023	0.035	0.041	0.028	0.049	0.030	0.062	0.103
(S_i)*(R_i)*(G_i)	0.025	0.018	0.030	0.063	0.060	0.063	0.095	0.106	0.119	0.119

Note: COV(X_i,$F(X)$) gives the covariance between the traffic distribution for carrier i and the cumulative distribution of total airport system traffic across all airports; COV(X_i*,$F(X$*)) gives the covariance between the traffic distribution for carrier i at airports in its network and the cumulative distribution of total airport system traffic across this subset of airports; COV(X_i*,$F(X_i$*)) gives the covariance between the traffic distribution for carrier i at airports in its network and the cumulative distribution of carrier i's traffic airports in it's network; COV(X_i,$F(X_i)$) gives the covariance between the traffic distribution for carrier i and the cumulative distribution of total airport system traffic across all airports.

TABLE 6

DECOMPOSITION COMPONENTS FOR EU25 CARRIERS IN 2006

	Air Berlin	KLM-Royal Dutch Airlines	SAS Scandinavian Airlines	Alitalia	Easyjet	Iberia	British Airways	Ryanair	Air France	Lufthansa German Airlines
Carrier Code	AB	KL	SK	AZ	U2	IB	BA	FR	AF	LH
Total Seats Available (Departing from EU25 airports)	17329351	17850366	17438757	28438070	36217927	38005655	43423997	49002408	57926063	60267753
Average seats per Airport	244075.4	357007.3	268288.6	546886.0	540566.1	542937.9	499126.4	426107.9	706415.4	792996.8
Standard Deviation	457129.9	1561089.8	855548.1	1455866.8	765179.1	1749222.0	2158971.2	1072342.7	2533299.2	2688184.3
Number of Airports Served	71	50	65	52	67	70	87	115	82	76
Cov(X_i,$F(X)$)	5770953	7627225	6482741	10841310	13732809	14820191	18568534	13593480	23325029	25756131
Cov(X_i*,$F(X^*)$)	12003746	12304348	13455752	20863800	18493020	25080561	27690078	27592772	35868845	39122654
Cov(X_i*,$F(X_i^*)$)	5917539	6400287	6941917	10582546	11556853	14649224	17487198	17090167	22468334	23943472
Cov(X_i,$F(X_i)$)	7918801	8394732	8228633	13422099	16276132	17713986	20148101	20927856	26709198	28136276
Concentration *Ratio*	0.666	0.855	0.743	0.762	0.758	0.780	0.855	0.555	0.805	0.855
Airports Served	71	50	65	52	67	70	87	115	82	76
Gini - served	0.683	0.717	0.796	0.744	0.638	0.771	0.805	0.698	0.776	0.795
Gini - all apts	0.914	0.941	0.944	0.944	0.899	0.932	0.928	0.854	0.922	0.934
S_i	0.026	0.026	0.026	0.042	0.054	0.056	0.064	0.073	0.086	0.089
R_i	0.729	0.909	0.788	0.808	0.844	0.837	0.922	0.650	0.873	0.915
O_i	2.029	1.922	1.938	1.972	1.600	1.712	1.583	1.615	1.596	1.634
n_i/N	0.293	0.207	0.268	0.215	0.276	0.289	0.358	0.472	0.337	0.313
N-n_i/N	0.707	0.793	0.732	0.785	0.724	0.711	0.642	0.528	0.663	0.687
$S_iR_iG_i*(n_i/N)$	0.004	0.004	0.004	0.005	0.008	0.010	0.017	0.016	0.020	0.020
$S_iR_i(N-n_i)/N$	0.013	0.015	0.019	0.027	0.033	0.034	0.038	0.025	0.050	0.056
$(S_i)*(R_i)*(G_i)$	0.017	0.019	0.023	0.032	0.041	0.044	0.055	0.040	0.069	0.076

Note: COV(X_i,$F(X)$) gives the covariance between the traffic distribution for carrier *i* and the cumulative distribution of total airport system traffic across all airports; COV(X_i*,$F(X^*)$) gives the covariance between the traffic distribution for carrier *i* at airports in its network and the cumulative distribution of total airport system traffic across this subset of airports; COV(X_i*,$F(X_i^*)$) gives the covariance between the traffic distribution for carrier *i* at airports in its network and the cumulative distribution of carrier *i*'s traffic airports in it's network; COV(X_i,$F(X_i)$) gives the covariance between the traffic distribution for carrier i and the cumulative distribution of total airport system traffic across all airports.

airports. There is a relatively lower degree of concurrence between carrier traffic distributions in Europe and the overall traffic distribution (as measured by R_i). This reflects the historic development of European air transport with a large set of bilateral agreements dictating the structure and capacity on intra-European routes until the mid-1990s. The carriers in Europe have tended to operate single hub systems, with air services to a relatively small number of European cities. Generally, air transport tended to be focused on the national capital and maybe one or two other large regional centres. The low R_i score for Ryanair (FR) arises as many of the airports in its network are secondary airports that are not highly ranked in the overall traffic distribution. Because of the very large size and coverage of US carriers, their networks tended to be closely correlated with the overall traffic distribution and this is reflected in generally very high *Ri* values in Table 5. The high *Oi* score however suggests that for the subset of airports served by Ryanair, the ordering of airports using traffic of all carriers is close to that of Ryanair. As the market share of a carrier increases, it would be expected that its traffic distribution would become more closely correlated with the overall distribution.

In Tables 7 and 8, the market overlap measure is decomposed by individual carriers in order to determine the extent of overlap among networks for pairs of carriers ranked in the top 10 (O_{ij}). Table 7 looks at the US carriers. In the pair wise comparisons of market overlap, the US carriers scores are generally higher, indicating a greater degree of multimarket contact between the carriers. The EU carrier scores average 0.67 while the US average score is 0.78. Among the US carriers, Alaskan and Southwest have the lowest scores indicating less competition generally across their networks from other large carriers. For American, America West, and United Airlines, there are high overlap scores with most of the other carriers indicating stronger competition particularly at the busier airports in their networks.

The European carrier measures of O_{ij} are given in Table 8. Ryanair's scores are the lowest showing relatively low levels of overlap throughout its network with other top 10 carriers. The highest overlap scores for Ryanair are with the other two LCCs

Table 7

FURTHER DECOMPOSITION OF O_i MARKET OVERLAP MEASURE FOR US CARRIER PAIRS IN 2006
(Ranking for Carrier *J*'s traffic distribution)

	FL	AS	HP	CO	US	NW	UA	AA	WN	DL
FL	1.00	0.68	0.73	0.81	0.81	0.79	0.73	0.79	0.58	0.88
AS	0.56	1.00	0.90	0.72	0.43	0.63	0.76	0.61	0.65	0.60
HP	0.73	0.89	1.00	0.88	0.67	0.80	0.92	0.84	0.91	0.80
CO	0.77	0.60	0.82	1.00	0.78	0.82	0.82	0.86	0.66	0.77
US	0.86	0.60	0.57	0.80	1.00	0.80	0.79	0.77	0.63	0.82
NW	0.79	0.55	0.78	0.79	0.67	1.00	0.81	0.79	0.64	0.75
UA	0.76	0.84	0.90	0.89	0.77	0.87	1.00	0.92	0.64	0.85
AA	0.83	0.73	0.85	0.87	0.78	0.83	0.88	1.00	0.64	0.88
WN	0.76	0.72	0.76	0.76	0.55	0.57	0.68	0.72	1.00	0.65
DL	0.87	0.61	0.71	0.81	0.73	0.79	0.77	0.81	0.60	1.00

Air Berlin(AB) and Easyjet (U2), as well as with BA. KLM's overlap scores are the highest of the EU25 carriers, since its relatively small network of airports is focused on the main European capital and large cities. Unlike BA, Lufthansa and Air France, the Dutch carrier has a relatively limited domestic market where it dominates a substantial regional traffic base.

Table 8

FURTHER DECOMPOSITION OF O_i MARKET OVERLAP MEASURE FOR EU25 CARRIER PAIRS IN 2006
(Ranking for Carrier *J*'s traffic distribution)

Carrier i	AB	KL	SK	AZ	U2	IB	FR	BA	AF	LH
AB	1.00	0.78	0.70	0.58	0.60	0.68	0.14	0.55	0.48	0.73
KL	0.70	1.00	0.93	0.85	0.85	0.81	0.21	0.91	0.86	0.86
SK	0.51	0.83	1.00	0.79	0.63	0.66	0.07	0.73	0.63	0.71
AZ	0.67	0.80	0.72	1.00	0.66	0.81	0.20	0.80	0.75	0.80
U2	0.64	0.64	0.53	0.43	1.00	0.66	0.56	0.62	0.46	0.38
IB	0.79	0.82	0.66	0.73	0.74	1.00	0.32	0.75	0.77	0.70
FR	0.50	0.37	0.27	0.24	0.45	0.29	1.00	0.45	0.28	0.17
BA	0.62	0.88	0.89	0.80	0.69	0.78	0.36	1.00	0.85	0.83
AF	0.55	0.74	0.64	0.59	0.72	0.72	0.14	0.62	1.00	0.80
LH	0.86	0.86	0.89	0.80	0.61	0.77	0.13	0.88	0.83	1.00

With consolidation likely in the next decade in the European air transport market and the growth associated with expansion of the European Union, some network structures are likely to evolve towards US Full Service Carrier (FSC) multiple interactive hub-and-spoke systems. The recent speculation over a possible merger of Lufthansa and Iberia is a case in point[5]. This type of merger would result in much larger carriers with a wider European and extra-European coverage. Currently however the US and EU25 markets have several distinguishing features that give rise to quite different network structures and traffic flow organisations. In the carrier specific tables, it has been shown that US carriers have lower levels of overlap with the total traffic distribution than do European carriers, but for individual carrier comparisons, there is greater overlap among any pair of US carriers compared to European carriers. Thus for the US carriers, their networks cover a more extensive set of airports and there is a lower degree of association with the overall traffic distribution than is the case in Europe. The large European carriers have networks focused on the largest airports in the European hierarchy; but there is less overlap or multimarket contact among pairs of individual European carriers. This would support the research presented by Gil-Molto and Piga (2007), which suggests that there has been limited entry activity and thus limited "effective competition" in some large European markets since liberalisation. The large European full service carriers have tended to focus their growth strategies on external (extra-EU25) route development, where they face less competition from other EU carriers and no competition to-date from LCCs. Further research is required to analyse the pricing implications of the evolving European carrier network strategies.

5. - Conclusions

As Europe completes the process of creating a single internal air transport market, airline network structure will continue to

[5] Reports of talks between Lufthansa and Iberia appeared in *La Tribune*, a French newspaper, on February 22nd 2007.

reflect the policy and historical parameters that have shaped the evolution of the system to date. This paper has examined the US and EU25 airports systems and looked in some detail at the network structures of the largest carriers in both systems. A number of key differences were highlighted between the two systems and the carriers operating within each market. The US market and US carriers are significantly larger in size and scale than European carriers. The US carrier's networks organise traffic flows around multiple hubs or focal cities in most cases and these hubs are located at significant distances from each other. The hubs act as regional centres for gathering and distributing air traffic flows through large continental systems in most cases. The LCC structures give rise to more dispersed traffic flow distributions, although the networks overlap to a moderately high degree with those of the FSC carriers.

European carrier networks in most cases continue to be focused on the capital city airport in the largest member states. The second busiest airport in EU25 FSC carrier networks tends to be located within the national territory also, and there are relatively low levels of interaction between the largest hubs in these cases. There tends to be less overlap among the networks of the European carriers, reflecting the regional specialisation within "home markets".

Both the US and European air transport systems have strong and growing LCCs among the top 10 carriers. The European LCCs have highly concentrated traffic flows but low levels of market overlap, reflecting the fact that they serve lower ranked airports or secondary airports at the largest urban centres, where they may be one of a very small number of operators. The European FSCs by contrast face competition from large numbers of other EU25 and non-EU25 carriers at the airports in their networks. This gives rise to high overall levels of market overlap, but relatively low levels of overlap when measured on a carrier by carrier basis.

Further analysis of differences in network structure and organisation is needed in order to characterise more precisely the nature of European carrier networks and more accurately compare and contrast strategies associated with alliance and merger impacts.

BIBLIOGRAPHY

ADLER N. - BERECHMAN J., «Evaluating Optimal Multi-Hub Networks in a Deregulated Aviation Market with an Application to Western Europe», *Transportation Research A*, no. 35 (5), 2001, pages 1-18.

BERECHMAN J. - DE WIT J., «Analysis of the Effects of European Aviation Deregulation on Airline's Network Structure and Choice of a Primary West-European Hub Airport», *Journal of Transport Economics and Policy*, no. 30 (3), 1996, pages 251-272.

BORENSTEIN S., «Hubs and High Fares: Dominance and Market Power in the US Airline Industry,» *RAND, Journal of Economics*, no. 20 (3), 1989, pages 344-365.

BORENSTEIN S. - ROSE N., «The Impact of Bankruptcy on Airline Service Levels», *American Economic Review Papers and Proceedings*, May 2003, pages 415-419.

BRUECKNER J.K. - SPILLER P.T., «Economies of Traffic Density in the Deregulated Airline Industry,» *Journal of Law & Economics*, no. 37 (2), 1994, pages 379-415.

BRUECKNER J.K. - WHALEN W.T., «The Price Effects of International Airline Alliances,» *Journal of Law and Economics*, no. 43, 2000, pages 503-545.

BRUECKNER J.K. - PELS E., «European Airline Mergers, Alliance Consolidation, And Consumer Welfare», *CESIfo, Working Paper,* no. 1154, 2004

BURGHOUWT G. - HAKFOORT J. - RITSEMA VAN ECK J., «The Spatial Configuration of Airline Networks in Europe», *Journal of Air Transport Management*, vol. 9, no. 5, 2003.

EVANS W.N - KESSIDES I.N., «Living by the "Golden Rule": Multimarket Contact in the US Airline Industry», *Quarterly Journal of Economics*, no. 109 (2), 1994, pages 341-366.

FOURNIER G. - ZUELKE T., *Price Effects of Reciprocal Multi-Market Contacts Among Airline Carriers*, paper presented at the 74th Annual Conference of the Southern Economics Association, New Orleans, November 2004.

GIL-MOLTO M.J. - PIGA C.A., «Entry and Exit in a Liberalized Market», *Rivista di Politica Economica*, no. I-II, 2007.

LEE D.L., «Concentration and Price Trends in the US Domestic Airline Industry: 1990-2000», *Journal of Air Transport Management*, no. 9, 2003, pages 91-101.

LERMAN R.I. - YITZHAKI S., «A Note on the Calculation and Interpretation of the Gini Coefficient», *Economics Letters,* no. 15, 1984, pages 363-368.

— — - — —, «Income Inequality Effects by Income Source: A New Approach and Application to the US», *Review of Economics and Statistics,* no. 67, 1985, pages 151-156.

MILANOVIC B. - YITZHAKI S., «Decomposing World Income Distribution: Does The World Have A Middle Class?», *Review of Income and Wealth*, no. 48, (2), 2002, pages 155-78.

REYNOLDS-FEIGHAN A.J., «Traffic Distribution in Low-Cost and Full-Service Carrier Networks in the US Air Transportation Market», *Journal of Air Transport Management*, no. 7 (5), 2001, pages 265-275.

— —, «Competing Networks, Spatial and Industrial Concentration in the US Airline Industry», *Spatial Economic Analysis*, no. 2 (3), 2007, pages 239-259.

YITZHAKI S., «Economic Distance and Overlapping of Distributions» *Journal of Econometrics*, no. 61, 1994, pages 147-159.

YITZHAKI S. - LERMAN R., «Income Stratification and Income Inequality» *Review of Income and Wealth*, 37, no. 3, (September), 1991, pages 313-329.